

Prehospital interventions performed in a combat zone: A prospective multicenter study of 1,003 combat wounded

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BACKGROUND:	Battlefield care given to a casualty before hospital arrival impacts clinical outcomes. To date, the published data regarding care given in the prehospital setting of a combat zone are limited. The purpose of this study was to describe the incidence and efficacy of specific prehospital lifesaving interventions (LSIs; interventions that could affect the outcome of the casualty), consistent with the Tactical Combat Casualty Care paradigm, performed during the resuscitation of casualties in a combat zone.
METHODS:	We performed a prospective observational study between November 2009 and November 2011. Casualties were enrolled as they were treated at six US surgical facilities in Afghanistan. Descriptive data were collected on a standardized data collection form and included mechanism of injury, airway management, chest and hemorrhage interventions, vascular access, type of fluid administered, and hypothermia prevention. On arrival to the military hospital, the treating physician determined whether an intervention was performed correctly and whether an intervention was not performed that should have been performed (missed LSI).
RESULTS:	A total of 1,003 patients met the inclusion criteria. Their mean (SD) age was 25 (8.5) years and 97% were male. The mechanism of injury was explosion in 60% of patients, penetrating in 24% of patients, blunt in 15% of patients, and burn in 0.8% of patients. The most commonly performed LSIs included hemorrhage control (n = 599), hypothermia prevention (n = 429), and vascular access (n = 388). Of the missed LSIs, 252 were identified with the highest percentage of missed opportunities being composed of endotracheal intubation, chest needle decompression, and hypotensive resuscitation. In contrast, tourniquet application had the lowest percentage of missed opportunities.
CONCLUSIONS:	In our prospective study of prehospital LSIs performed in a combat zone, we observed a higher rate of incorrectly performed and missed LSIs in airway and chest (breathing) interventions than hemorrhage control interventions. The most commonly performed LSIs had lower incorrect and missed LSI rates. (<i>J Trauma Acute Care Surg.</i> 2012;73: S38–S42. Copyright © 2012 by Lippincott Williams & Wilkins)
LEVEL OF EVIDENCE:	Prognostic study, level III.
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The care rendered to a casualty in the prehospital setting can influence all subsequent medical interactions and the overall outcome of the patient. Historically and from current published data on Overseas Contingency Operations, most combat-related deaths occur in the prehospital setting before the casualty reaches a military medical facility.^{1–3} As part of an evolving medical system, we must continuously improve the medical care administered to casualties in the prehospital

phase. A key component of improving prehospital care should be based on what important procedures are performed in the field. Unfortunately, published studies from the prehospital setting in a combat zone are limited.^{4–7} In their retrospective review of the Joint Theater Trauma Registry, Therien et al.⁸ observed that only 24% of the studied population had any prehospital data within their medical records. This lack of prehospital data creates limitations for educators who attempt to modify training programs to address the challenges encountered, such as skill competence and skill degradation. Published literature demonstrated that skill degradation is a challenge faced by civilian prehospital systems.^{9,10} De Lorenzo and Abbott¹¹ hypothesized that a focused and directed continuing education program can successfully overcome the challenges of skill degradation. When designing a continuing education program, we require field data on skill performance to ensure that the improvements implemented are clinically effective. Kotwal et al.¹² were successful in creating a prehospital trauma registry for the 75th Ranger Regiment. Analysis of this data facilitated performance improvements in Tactical Combat Casualty Care (TCCC) within the 75th Ranger Regiment centered on clinical outcomes.¹² Unfortunately, this program only focuses on the

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75th Ranger Regiment and does not capture lifesaving interventions (LSIs) that were not performed in the prehospital setting, yet should have been performed (i.e., a “missed LSI”).

Tactical Combat Casualty Care is a key component of battlefield medicine in the prehospital setting, focusing on the treatment of preventable causes of battlefield death.¹³ The guidelines published by the TCCC Committee are used by all services in the Department of Defense, ensuring that the best care is given to those wounded on the battlefield.¹⁴

The first step toward understanding the current global state within the prehospital, presurgical combat casualty care setting is to collect and analyze data on what procedures are being performed. The purpose of our study was to determine the incidence of LSIs performed, the missed opportunities to intervene with a LSI, and the success of LSIs that are performed in the prehospital setting of a combat environment.

METHODS

Study Design

The Brooke Army Medical Center Institutional Review Board approved this prospective observational study. The study was performed at approved US military medical facilities in Afghanistan between November 2009 and November 2011. Casualties who were transported to a participating facility from the field were included. Casualties were excluded if they were transferred from another medical facility or were detainees. After appropriate medical care was provided to the casualty, the subject was enrolled using a standardized collection form. The treating physician determined (1) whether an intervention was performed correctly and/or (2) whether it was indicated. The physician also determined whether an intervention was not performed in the prehospital setting that should have been performed, defined as a missed LSI.

Demographic data including age and sex were recorded. Descriptive data recorded included mechanism of injury defined as penetrating (gunshot wound or stabbing), blunt trauma (i.e., motor vehicle crash, fall), isolated burn from nonblast mechanism, and explosive mechanism. Documentation of pre-



Figure 2. Casualty with tourniquet and combat gauze dressing used to control hemorrhage.

hospital vital signs and LSIs performed including airway management, chest, and hemorrhage interventions. In April 2010, the study was amended with addition of the following data points beginning in June 2010: vascular access, type of fluid administered, hypothermia prevention, and whether a TCCC card (DA 7656) was turned in to the receiving facility.

The specific LSIs by category included were the following:

- Airway management: nasal or/oral airway insertion, endotracheal intubation, and surgical cricothyroidotomy.
- Chest interventions: chest needle decompression, chest tube placement, and chest seal application.
- Hemorrhage interventions: tourniquet application, use of pressure packing (nonhemostatic agent), and use of pressure packing (with a hemostatic agent).
- Resuscitation: vascular access, type of fluid administered, hypotensive resuscitation, and hypothermia prevention.

All data were analyzed with descriptive statistics.

RESULTS

We enrolled 1,003 patients who had a mean (SD) age of 25 (8.5) years, most of whom (97%) were male. The mechanism of injury was explosion in 602 (60%), penetrating in 238 (24%), blunt in 155 (15%), and isolated burn in 8 (0.8%). With regard to airway management, 27 (2.7%) casualties had a nasal or oral airway placed, 28 (2.8%) underwent endotracheal intubation, and 15 (1.5%) had a surgical cricothyroidotomy performed. When evaluating chest interventions, 12 (1.1%) underwent a needle chest decompression, 6 (0.6%) had a chest tube placed, and 12 (1.2%) had a chest seal applied. Airway and chest (breathing) interventions made up the lowest percentage of performed LSIs (Fig. 1).

With regard to hemorrhage control, 166 casualties (17%) had 205 tourniquets applied, 371 (37%) had pressure packing without hemostatic agent, and 23 (2.3%) had pressure packing with hemostatic agent applied (Fig. 2). Although the exact

Prehospital LSIs Performed

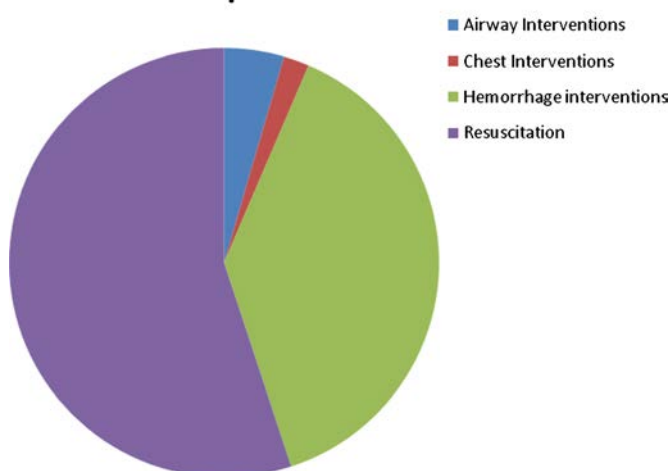


Figure 1. Prehospital LSIs performed.

TABLE 1. List of the Intravenous Fluids Administered in the Field (June 2010 to November 2011)

Fluid Administered	Casualties, n (%)
NS	168 (73.3)
Lactated Ringer's	39 (17.3)
Colloids	19 (8.4)
Other	2 (1)

Colloids included Hextend, Hespan, and Pentaspan.

hemostatic dressing applied was not documented, the treating physician identified that the dressing was lifesaving in 13 (57%) of 23 applications. Hypotensive resuscitation was implemented in the care of 39 (3.9%) casualties.

The study was amended in April 2010 with data collection beginning in June 2010, adding the following data points: vascular access, type of fluid administered, hypothermia prevention, and whether a TCCC card was turned in to the receiving facility. After this amendment, 692 casualties were enrolled. Vascular access was attempted in 388 (56%) of the casualties; the type of intravenous fluid administered in the field was available for 223 of the 388 casualties. The most commonly infused fluid was normal saline (NS; Table 1). Three casualties received both NS and Hextend and two casualties received lactated Ringer's and NS. Prehospital hypothermia prevention was used in 429 casualties (62%), with the type of hypothermia prevention recorded for 390. The most commonly used method of hypothermia prevention included a wool blanket (326 [84%] of 390), followed by space blanket (33 [8.5%] of 390), and the hypothermia prevention and management kit (HPMK; 22 [5.6%] of 390). There were six casualties that had two methods used: four with a wool blanket in addition to a space blanket, one with a wool blanket and an HPMK, and one with a wool blanket and a body bag. A TCCC card was turned in at the receiving facility for 95 (14%) of the casualties.

Prehospital documentation of vital signs including heart rate, respiratory rate, or blood pressure was noted in 223 (22%) of the casualties enrolled. Of these, 99 (44%) had a complete set of prehospital vital signs documented.

TABLE 2. Incorrectly Performed LSIs in the Prehospital Setting of a Combat Zone

	No. Incorrectly Performed LSIs	Total No. Performed LSIs	Percentage of Incorrectly Performed LSIs
Airway interventions*	6	70	8.6
Vascular access†	31	388	8.0
Chest procedures*	2	30	6.7
Tourniquet placement*	12	205	5.9
Hypothermia prevention†	1	429	0.2

*Data collected from November 2009 to November 2011.

†Data collected from June 2010 to November 2011.

TABLE 3. Missed LSIs

	No. Missed LSIs	Total No. Performed and Missed LSIs	Percentage of Missed LSIs
Endotracheal intubation*	32	60	53
Chest needle decompression*	11	23	48
Hypotensive resuscitation*	30	69	43
Nasal/oral airway*	10	37	27
Vascular access†	99	487	20
Pressure packing with hemostatic agent*	4	27	15
Chest tube*	1	7	14
Surgical cricothyroidotomy*	2	17	12
Pressure packing with out hemostatic agent*	35	406	9
Chest seal*	1	13	8
Hypothermia prevention†	26	455	5.7
Tourniquet*	1	206	0.5

Missed LSIs are defined as interventions that were not performed in the prehospital setting that should have been performed.

*Data collected from November 2009 to November 2011.

†Data collected from June 2010 to November 2011.

The most common incorrectly performed LSIs were airway interventions, vascular access, and chest procedures (Table 2). The incorrectly performed airway intervention procedures included two endotracheal intubations, two surgical cricothyroidotomies, and two nasal/oral airway insertions. When evaluating tourniquet placement, 12 of 205 were placed incorrectly; 10 of these were loose with continued hemorrhage and 2 were placed distal to the injury. In addition, six patients (3%) were identified by the treating physician as having a tourniquet placed when it was not indicated. One case of in correctly used hypothermia prevention was identified, in which the casualty suffered burns from the HPMK. There were a total of 252 missed LSIs documented; the most common were endotracheal intubation, chest needle decompression, and hypotensive resuscitation (Table 3).

DISCUSSION

To our knowledge, this study represents the largest quantitative and prospective analysis of prehospital LSIs conducted in the contemporary combat setting. Our study suggests that some prehospital lifesaving procedures are performed infrequently in a combat zone, as with civilian emergency medical services. The lower rate of performance of these LSIs may result in skill degradation and thus a lower success rate and higher rate of missed opportunity to perform the LSI. Wang et al.¹⁵ reported that 3.8% of patient care events undergo an airway management intervention. In their study of advanced scope-of-practice emergency care and LSIs in combat, Gerhardt et al.⁶ identified a rate of 4.5% for advanced airway management and 6% underwent a chest intervention. Our study revealed that

7% of the casualties enrolled underwent an airway intervention and 3% underwent a chest intervention. These two areas also accounted for two of the three highest rates of missed LSIs documented in our study (Table 3). Previous studies report that acute airway obstruction or ventilatory failure account for 10% to 15% of potentially survivable injuries in combat.³ Airway interventions accounted for the highest rate of incorrectly performed interventions in our study with a rate of 8.6% (Table 2). With this knowledge, these areas may benefit from additional focus in basic and continuing education programs for prehospital providers.

In contrast, prehospital hemorrhage control interventions in the combat setting were observed at a higher rate, with 17% of the enrolled casualties requiring a tourniquet and 39% requiring pressure packing with or without hemostatic agent. Furthermore, the rate of missed LSIs for tourniquet application was the lowest recorded during the study (Table 3).

The results of the study also shed light on the current compliance with some areas of the TCCC recommendations. The current TCCC guidelines recommend Hextend as the intravenous fluid of choice when resuscitating a casualty, but in our study, NS (Table 1) was the most commonly used fluid.¹⁶ In addition, the TCCC card is rarely turned into the receiving facility, which our data suggests only occurs 14% of the time.

The rates of the different missed LSIs noted (Table 3) also highlight an important area for advancement of battlefield care. The identification of areas for improvement is fundamental to address shortcomings within any system. A way to continuously evaluate trends of care rendered on the battlefield includes the establishment of a prehospital performance improvement system. A key aspect in the development of such a system would involve the creation of a prehospital registry to assist in the analysis of trends of care rendered. In addition, the system would also require the leadership and knowledge of subject matter experts in the field of emergency medical service to oversee the system as its medical director.

As we continue to focus on saving lives on the battlefield, prehospital data will allow us to continue to address areas of where we can intervene and decrease the incidence of potentially survivable deaths. Kelly et al.³ reported in their study potentially survivable rates of 19% and 28%; as the combat medical care system continues to improve, we must lower those numbers.

The results of our study suggest a higher level of proficiency for the interventions performed more often (Table 4).

TABLE 4. Comparison of Missed, Incorrectly Performed, and Number of Performed LSIs for Airway, Chest, and Hemorrhage Control Interventions (November 2009 to November 2011)

	Percentage of Missed LSIs	Percentage of Incorrectly Performed LSIs	No. Performed LSIs
Airway interventions	39	8.6	70
Chest procedures	30	6.7	30
Hemorrhage control	6.3	2	599

This information could be used by educators to help tailor continuing education programs for medics to ensure that global skill maintenance is sustained.

LIMITATIONS

The primary limitation is that the study was a convenience sample. This was not a consecutive enrollment study because of the challenges of performing this study in a combat zone. Also, given the lack of comprehensive prehospital medical record data for the Theater of Operations, we cannot confirm the true denominator of our population—those dying before arrival at our study facilities, or who were transported elsewhere, were not captured. This limitation is mitigated to some extent by our large sample size. Other limitations include the descriptive nature of the study, the lack of outcome data, the subjective nature of determining the need for an LSI by the treating physician, and the inability to estimate the interphysician validity when determining that an LSI was performed incorrectly or a missed LSI was documented. In addition, we cannot ascertain the level of training by the provider who performed the LSI in the prehospital setting, although we can state that all of the patients were cared for by a medic/hospital corpsman during transport to the enrolling military medical facility. In addition, our study does not take into account the tactical situation that may have been encountered by the prehospital provider.

CONCLUSIONS

In our study describing prehospital LSIs performed in a combat zone in 1,003 patients wounded in combat, we observed a higher rate of incorrectly performed and missed LSIs in airway and chest (breathing) interventions than hemorrhage control interventions. The most commonly performed LSI had lower incorrect and missed LSI rates.

Basic and sustainment training with continuing medical education for prehospital combat providers should focus on the less common LSIs including airway and chest LSIs, and review of more commonly performed interventions including hypotensive resuscitation.

Investigation of potential mitigation strategies to improve prehospital LSI performance, including improved clinical training of practitioners, professional medical oversight, and uniform implementation of TCCC guidelines, is warranted. Continued surveillance of battlefield prehospital care to provide metrics for quality improvement as well as for completion of health records remains a challenge to implement but should be emphasized in future Force Health Protection resource allocation.

AUTHORSHIP

J.R.L. and L.H.B. designed this study, for which J.R.L. and P.T. conducted literature searches. V.S.B., C.J.B., K.F.L., T.R., E.M.R., and W.F. collected data; J.R.L., V.S.B., P.T., J.M., and L.H.B. performed data analysis; and J.R.L., V.S.B., R.G., and L.H.B. interpreted the data. J.R.L., V.S.B., C.J.B., K.F.L., T.R., E.M.R., B.T.K., W.F., R.G., F.B., J.D., R.C., J.S., and L.H.B. wrote the manuscript. J.R.L. and L.H.B. produced figures.

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DISCLOSURE

The views expressed in this article are those of the authors and do not reflect the official policy or position of the Department of the US Air Force, Department of the US Army, Department of the US Navy, Department of Defense, or the US government.

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